Technology Selection and Prioritization Process for the ExEP 2018 Technology Gap List

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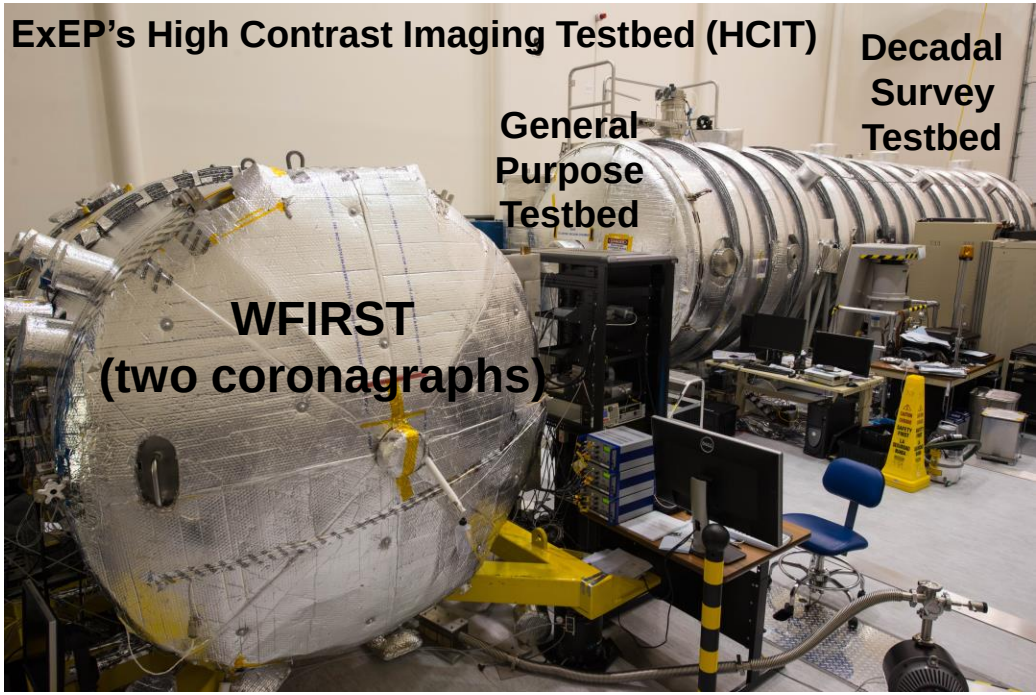
Program Technology Updates Since Last ExoPAG

1. TDEM update https://exoplanets.nasa.gov/exep/technology/TDEM-awards/

- TDEM-15 Breckinridge: SOW developed and Milestone Whitepaper approved by ExoTAC
- TDEM-10 Bierden: MEMs DMs pre-environmental characterization completed and shipped for environmental testing at GSFC
- TDEM-14 Serabyn: Vector Coronagraph demonstration in HCIT starting in July (10^{-9} contrast goal at 3 λ/D, 10% band with charge-4 and charge-6 masks)



2. Decadal Survey Testbed

- Program Office is upgrading one of the High-Contrast Imaging Testbeds to enable future users to perform coronagraph demonstrations at the 10^{-10} contrast level
  - Peer Review of testbed design and goals for Phase 1 conducted
  - 1st light for unobscured demo scheduled for Feb 2018, completion by end FY18
  - Phase II: Segmented on-axis demonstration scheduled to start in October 2018

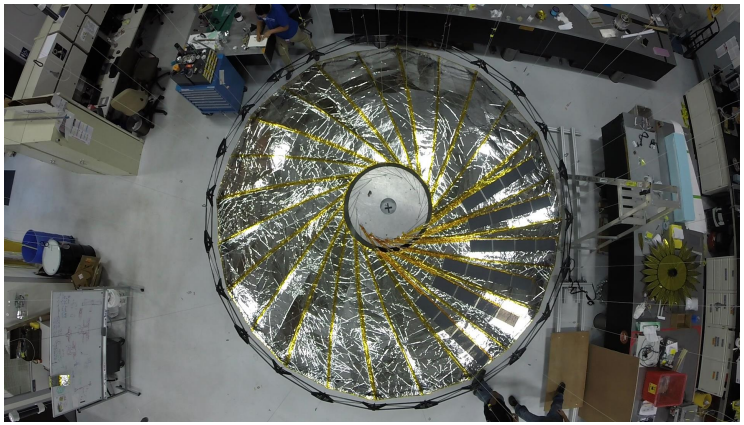
Program Technology Updates Since Last ExoPAG

3. TRL assessments for large mission STDTs

- Worked with other APD program offices and Aerospace to assess Technology Readiness Level (TRL) of technology needs of LUVOIR, HabEx, OST, and Lynx.

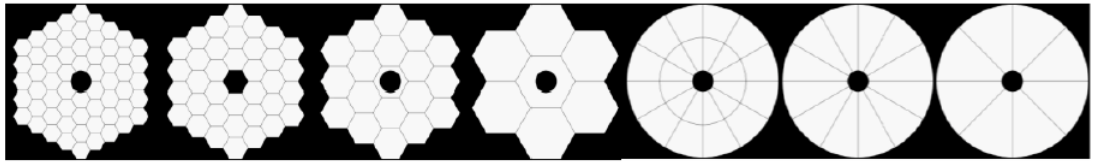
4. Starshade

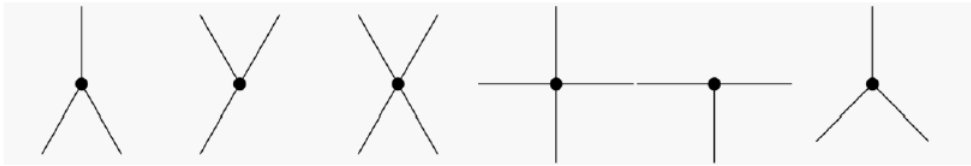
- Paul Hertz directed the WFIRST mission to continue studying starshade compatibility
- Two workshops at JPL: Starshade Scattered Sunlight Control, Starshade Mechanical Architecture



5. Segmented Coronagraph Design & Analysis study

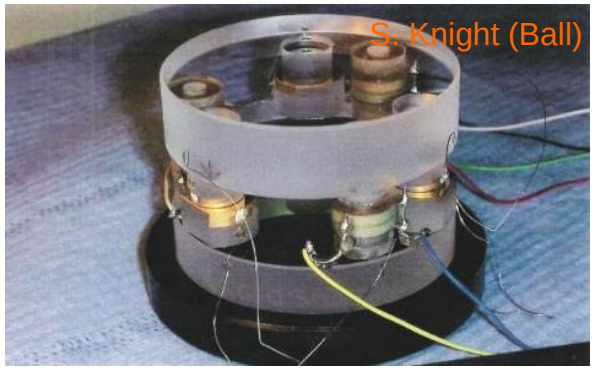
- APLC design is most successful so far with apertures under consideration;
- APLC robustness against design tolerances being evaluated; Vortex being optimized for finite star size and on-axis secondary; PIAACMC considered for longer-wavelength use.
- Next design round to include realistic errors (e.g. segment phase errors and SFE)

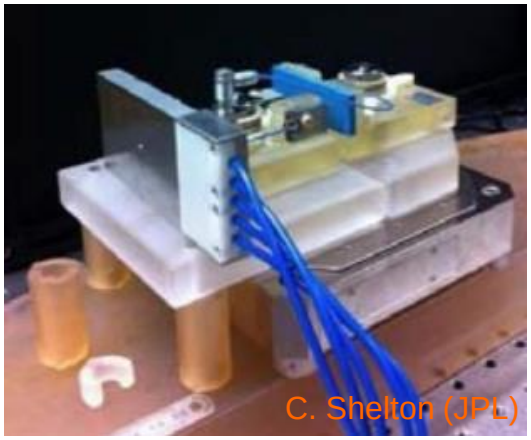


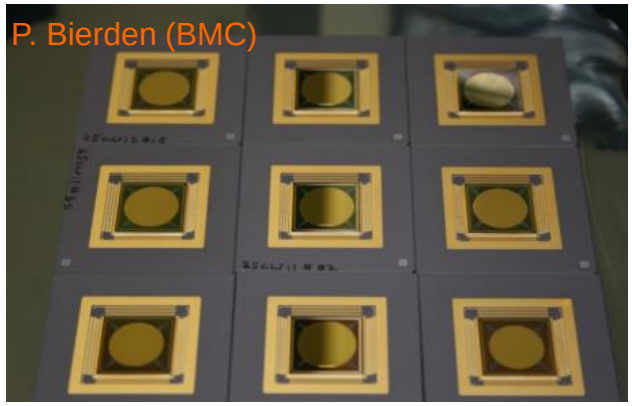


Program Technology Updates Since Last ExoPAG

6. **ExEP Technology Colloquium Series continues https://exoplanets.nasa.gov/exep/technology/tech_colloquium/**
   - Mirror segment edge-sensing technology, colloidal microthrusters, MEMS DMs







7. **Annual Technology Selection and Prioritization Process starts now!**

Exoplanet Missions

First high-contrast coronagraph in space; starshade accommodation under study

WFIRST

JWST[2]

TESS

PLATO

Kepler

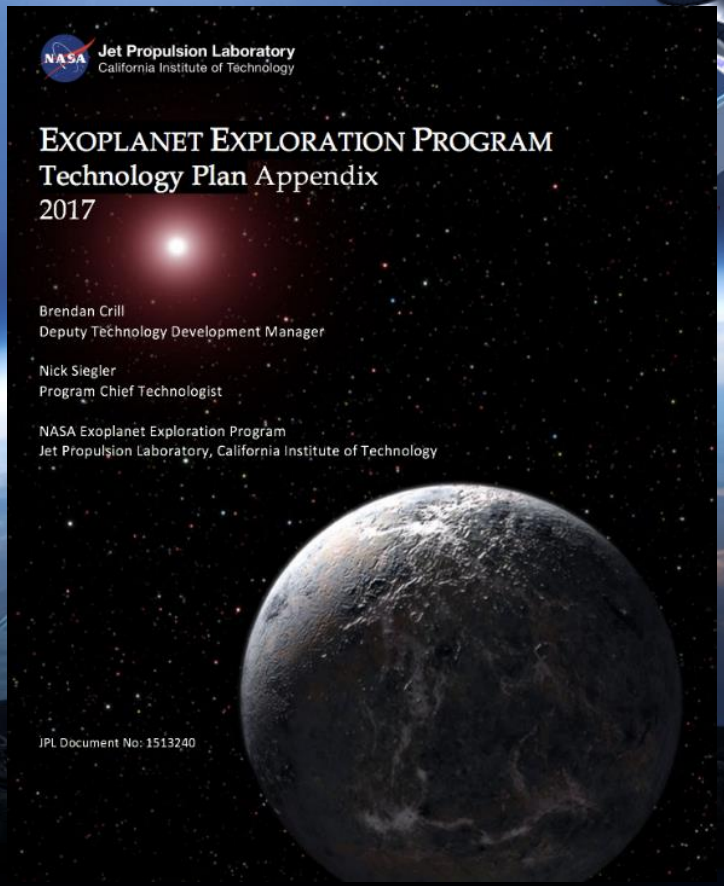
CHEOPS

Gaia

New Worlds Telescope

CoRoT[3]

ESA/European Missions



2020 Decadal Survey Mission Concept Studies

- Origins Space Telescope
- HabEx Imaging Mission
- LUVOIR Surveyor
- Lynx

Probe Studies with Exoplanet focus

- WFIRST/Starshade Rendezvous (S. Seager)
- Radial Velocity Instrument (P. Plavchan)

Technology Gaps Selection Criteria

1. **Technology gaps considered for tracking and development by the ExEP must support APD exoplanet science missions as:**
   - defined by the needs of the 2010 Decadal Survey as described in the Astrophysics Implementation Plan;
   - directed through the Science Mission Directorate;
   - selected through open competition; or
   - described in the APD 30-year roadmap.

2. **The subset of these gaps that enables or enhances exoplanet science are selected and prioritized onto the ExEP Technology Gap List**
   - Technologies that address these gaps are the ones prioritized for development and considered for resource allocation
   - The list is published in the annual Technology Plan Appendix
   - Some of these technologies may be funded outside of the ExEP

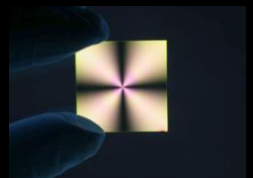
Technology Selection and Prioritization Process

Exoplanet Exploration Program

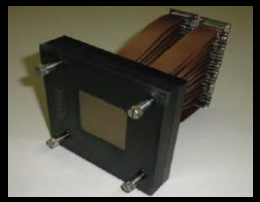
ID	Activity	
1	Technology needs input window opens	06/18/17
	email ExoPAGannounce: Technology Gap Lists, input forms, process explanation	06/09/17
	presentation at June ExoPAG	06/18/17
2	Technology window closes	08/28/17
3	Technology Gap Selection and Prioritization Criteria Review by APD Program Offices	08/25/17
4	Selection and Prioritization Criteria Review by ExoTAC	09/05/17
5	Technology Gap Assessment Review by APD Program Offices	09/18/17
6	Technology Gap Assessment Review by ExoTAC	10/02/17
7	Technology Gap Lists inform TDEM Amendment	mid-Nov
8	Technology Amendment released through NSPIRES	mid-Dec
9	ExEP Technology Plan Appendix updated and released	12/01/17
	Presentation at January ExoPAG	01/06/18
10	TDEM Proposal Deadline	03/15/18
11	TDEM Awards Selected	Aug 2018

The Enabling Coronagraph/Telescope Technology Needs

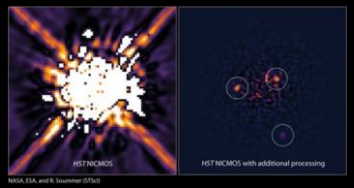
Contrast



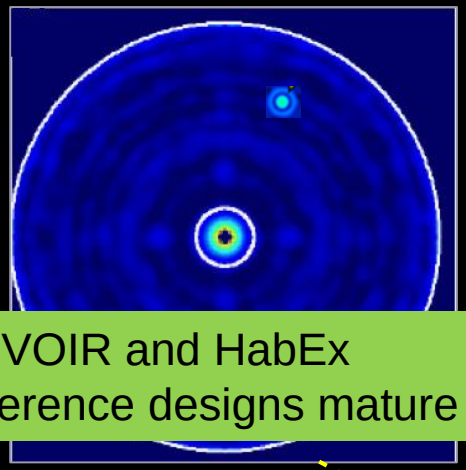
CG-2: Coronagraph Demonstrations and Modeling



CG-3: Deformable mirrors

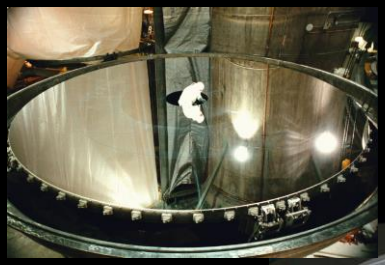


CG-4: Image post-processing



LUVOIR and HabEx reference designs mature

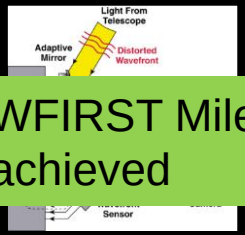
Angular Resolution



CG-1: Large monolith mirrors

CG-1: Segmented mirrors

Contrast Stability



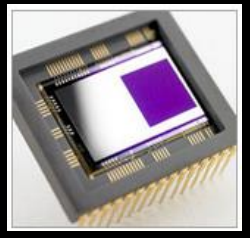
WFIRST Milestone 9 achieved

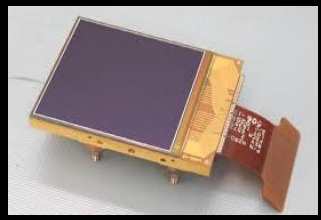
CG-5: Wavefront sensing and control

CG-6: Segment phasing and rigid body sensing and control

CG-7: Telescope vibration sensing and control

Detection Sensitivity



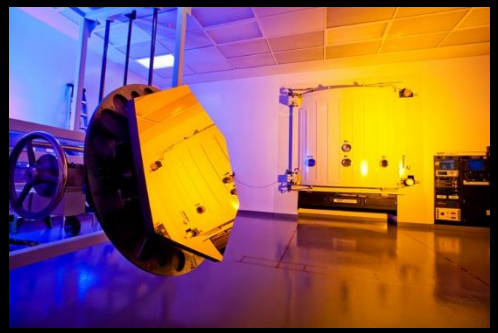


Ultra-low noise visible (CG-8) and infrared (CG-9) detectors

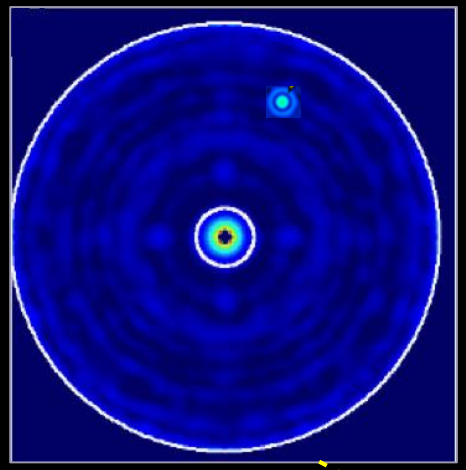
The Enhancing Coronagraph/Telescope Technology Needs

Contrast

CG-11 Mid Infrared Spectral Coronagraph



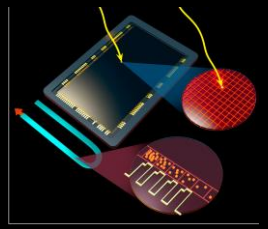
CG-10 UV/Vis/NIR mirror coatings



Mission Efficiency

M-1: Ultra-high precision Radial Velociity

Detection Sensitivity



Ultra-low noise UV detectors (CG-12)

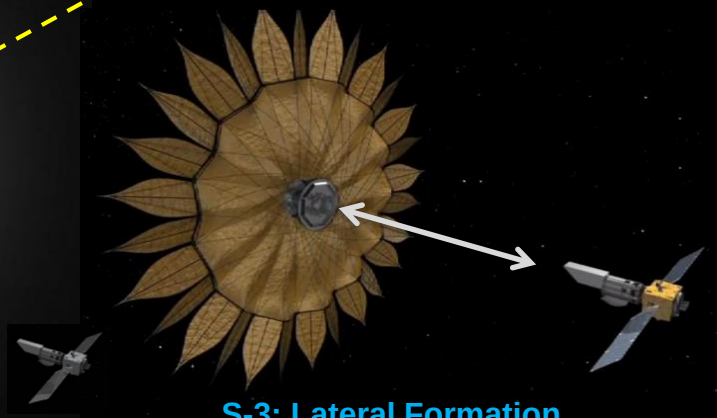
Starshade Technology Needs

Starlight Suppression

S-1: Controlling Scattered Sunlight

Starshade Rendezvous Probe Study selected

Formation Sensing and Control



S-3: Lateral Formation Sensing

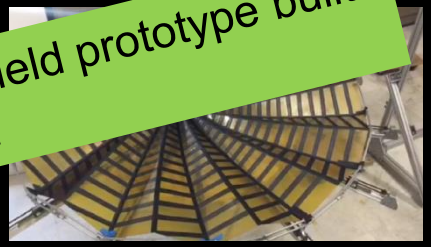
Princeton optical demo reaches 3e-8 contrast; work continues

S-2: Starlight Suppression and Model Validation

Deployment Accuracy and Shape Stability

SBIR-1 awarded to Tendeg for deployment motor

5 m optical shield prototype built and deployed

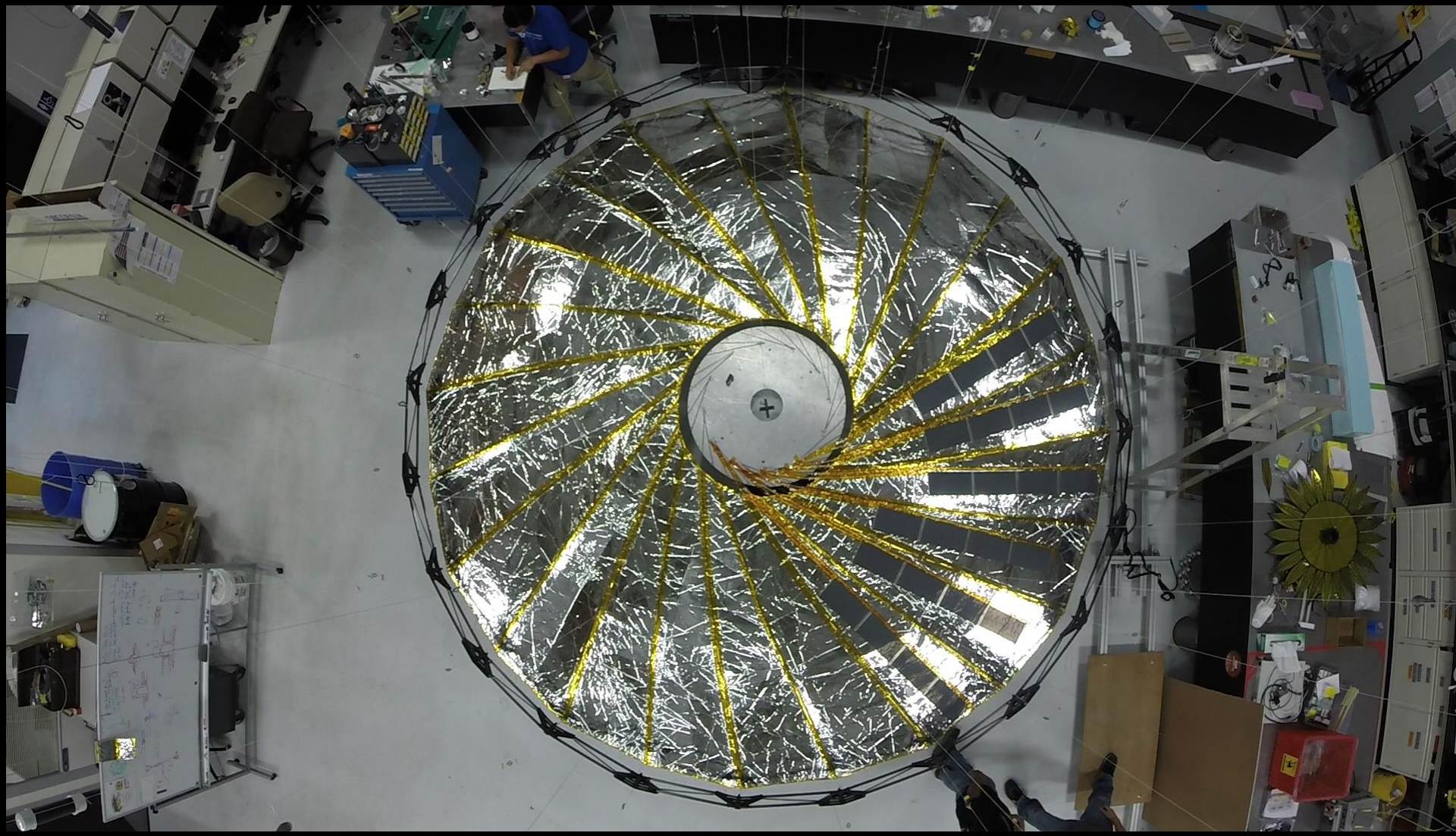


S-5: Petal Positioning Accuracy and Opaque Struc

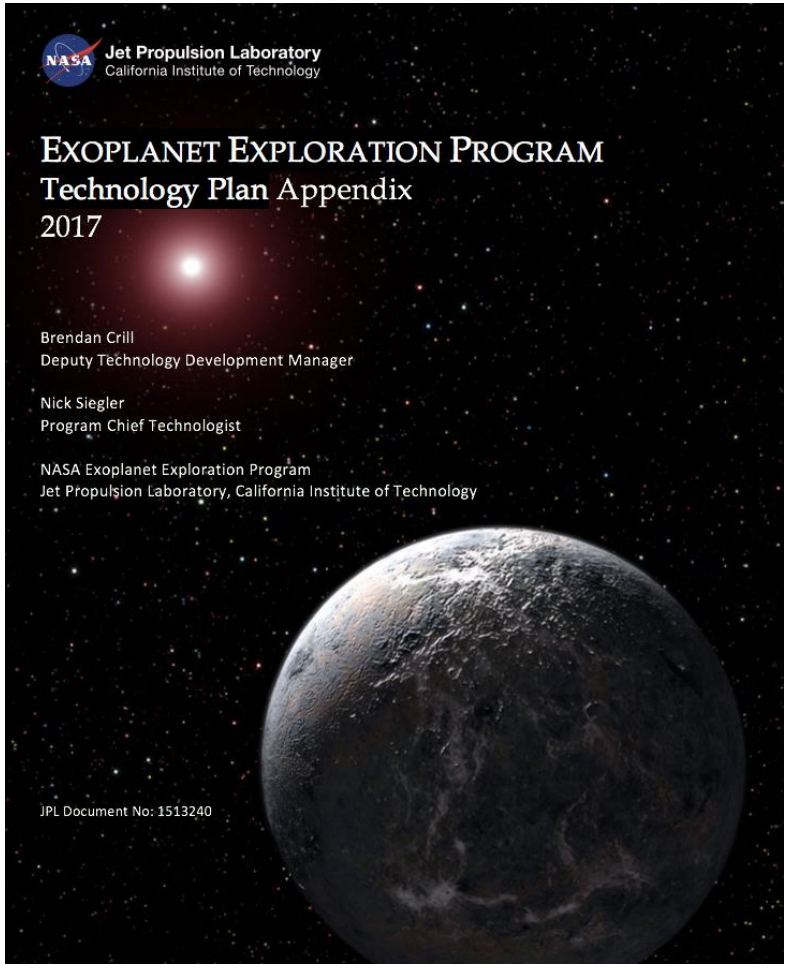
NGAS studying alternative deployment approach

Stability

5m Starshade Optical Shield Prototype



ExEP Technology Plan Appendix



Next update: January 2018

Gap ID	Gap Title
S-2	Starlight Suppression and Model Validation
S-1	Control Edge-Scattered Sunlight
S-3	Lateral Formation Flying Sensing
S-4	Petal Shape
S-5	SS Deployment and Shape Stability
CG-1	Large Aperture Mirrors
CG-2	Coronagraph Architecture
CG-6	Mirror Figure / Segment Phasing, Sensing & Control
CG-7	Telescope Vibration Control
CG-9	NIR Ultra-Low Noise Detector
CG-3	Wavefront Sensing and Control
CG-5	Deformable Mirrors
CG-8	Visible Ultra-Low Noise Detector
M-1	Extreme Precision Radial Velocity
CG-4	Post-Data Processing
CG-10	UV/NIR/Vis mirror coatings
CG-11	Mid-IR Spectral Coronagraph
CG-12	UV Ultra-low noise detector

Enabling Technology
Enhancing Technology

https://exoplanets.nasa.gov/exep/technology

Did we miss anything?

Additional Slides

2017 ExEP Technology Gap List

Exoplanet Exploration Program

Prioritized List

Gap ID	Gap Title	Impact	Urgency	Trend	Total
	Weight:	10	10	5	
S-2	Starlight Suppression and Model Validation	4	4	2	90
S-1	Control Edge-Scattered Sunlight	4	4	2	90
S-3	Lateral Formation Flying Sensing	4	4	2	90
S-4	Petal Shape	4	4	2	90
S-5	SS Deployment and Shape Stability	4	4	2	90
CG-1	Large Aperture Mirrors	4	3	3	85
CG-2	Coronagraph Architecture	4	3	3	85
CG-6	Mirror Figure / Segment Phasing, Sensing & Control	4	3	3	85
CG-7	Telescope Vibration Control	4	3	3	85
CG-9	NIR Ultra-Low Noise Detector	4	3	3	85
CG-3	Wavefront Sensing and Control	4	3	2	80
CG-5	Deformable Mirrors	4	3	2	80
CG-8	Visible Ultra-Low Noise Detector	4	3	2	80
M-1	Extreme Precision Radial Velocity	3	3	3	75
CG-4	Post-Data Processing	4	2	2	70
CG-10	UV/NIR/Vis mirror coatings	3	3	2	70
CG-11	Mid-IR Spectral Coronagraph	2	3	3	65
CG-12	UV Ultra-low noise detector	2	3	2	60

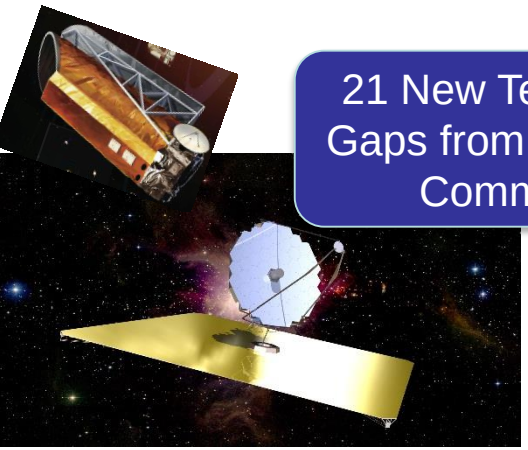
Enabling Technology
Enhancing Technology
Watch List

Watch List

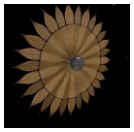
Sub-Kelvin Coolers
Advanced Cryocooler
Mid-IR Ultra-low Noise Detector
Astrometry

Technology Selection and Prioritization Process

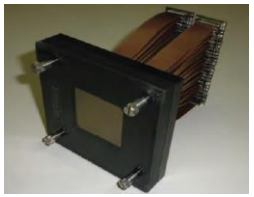
Exoplanet Exploration Program

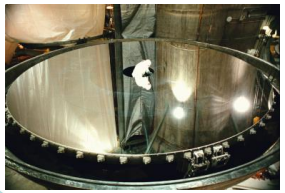


21 New Technology Gaps from Exoplanet Community



14 Technology gaps carried over from 2016





Selection: enables or enhances direct detection and characterization of exoplanets?

Neither enhancing nor enabling

not accepted

Selection and Prioritization Criteria:

- Peer reviewed
- Exo-TAC reviewed

Yes

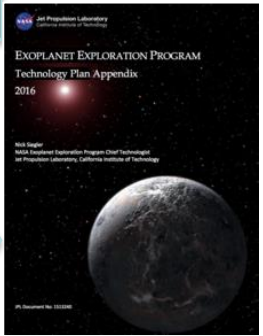
Prioritize technologies according to criteria (Impact, Urgency, and Trend)

No, but could benefit exoplanet science

Watch List

ExEP Technology Gap List

Reviewed by Exo-TAC



2017 Prioritization Criteria

Impact (weight: 10)	4: Critical technology - required to meet mission concept objectives; without this technology, applicable missions would not launch
	3: Highly desirable - not mission-critical, but provides major benefits in enhanced science capability, reduced critical resources need, and/or reduced mission risks; without it, missions may launch, but science or implementation would be compromised
	2: Desirable - not required for mission success, but offers significant science or implementation benefits; if technology is available, would almost certainly be implemented in missions
	1: Minor science impact or implementation improvements; if technology is available would be considered for implementation in missions

Urgency (weight: 10)	4: reduced risk needed for missions currently in pre-formulation or formulation.
	3: In time for the Decadal Survey (2019); not necessarily at some TRL but reduced risk by 2019.
	2: Earliest projected launch date < 15 yr (< 2030)
	1: Earliest projected launch date > 15 yr (> 2030)

Trend (weight: 5)	4: (a) no ongoing current efforts, or (b) little or no funding allocated
	3: (a) others are working towards it but little results or their performance goals are very far from the need, (b) funding unclear, or (c) time frame not clear
	2: (a) others are working towards it with encouraging results or their performance goals will fall short from the need, (b) funding may be unclear, or (c) time frame not clear
	1: (a) others are actively working towards it with encouraging results or their performance goals are close to need, (b) it's sufficiently funded, and (c) time frame clear and on time

Footnote: to be deemed “ready,” the technology is available to NASA at TRL 6 by the earliest possible Preliminary Design Review (PDR) of a mission; or at TRL 5 by the start of Phase A